



Social Robots

2016's new breed of
social robots is ready
to enter your world

Advisory

2016

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Preface

A long time ago, in a galaxy far, far away... C3PO moves with haste through the desert sands of planet Tatooine with his fellow droid R2-D2. He has the size of an average man, its limbs covered with golden plating, eyes filled with small lights and a soft gentle voice. C3PO is a 3PO unit protocol droid designed to interact with organics, programmed primarily for etiquette and protocol. Driven by a desire to service its master, it is able to make autonomous choices and displays true emotion and empathy when his master is in trouble. C3PO is a true social robot, autonomous, empathic, operating within a set of boundaries and able to weigh various alternatives and make decisions.

Robot stories have been around for ages. In 1495 Leonardo Da Vinci designed the Mechanical Knight, a humanoid automation for the battlefield. Some people may perceive robots as dangerous technological ventures that someday may threaten the existence of the human race (pretty much the plot of most movies that contain robots), by taking over the world or turning people into technology dependent beings while robots do all the work. The term 'robot' actually comes from a play about mechanical assembly line workers that rebel against their human masters. Robots entered literature in 1868, in the science fiction novel 'The Steam Man of the Prairies', where a mechanical metal man with a steam boiler inside pulls a carriage. Robots started to appear in books and movies and have intrigued human beings ever since.

Today robots, and especially the social kind, have traded in the movie studios for our daily lives. We see a rapid development of social robot concepts that are tailored to professional and consumer use. It is not unlikely you that you will cross paths with a social robot at an airport check-in, in a hotel or in an elderly care environment in the near future.

The introduction of social robots in society, work and homes fuels various discussions ranging from the dark side of artificial intelligence to the future of work and the impact on social interactions. In this article we introduce a set of drivers for the adoption of social robots.

As with many changes driven by technology, there is no question if but when we will see the first applications in our daily lives. This raises all kinds of questions, of which one of the most interesting ones will be whether there will be a recognizable border between humans and robots. If in fact robots are already integrating with humans as we speak, will robots have rights and obligations just like we do? Asimov already thought about this topic in his short story "Runaround" back in 1942. According to his 'Handbook of Robotics', robots should abide to 'The Three Laws':

1. A robot may not injure a human being, or through interaction, allow a human being to come to harm
2. A robot must obey the orders given it by human beings except where such order would conflict with the First Law
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws

These are interesting rules to ponder, especially in times where drones carry out strikes and defence robots are installed to patrol our borders. I invite you to read the interviews with the start-up CEOs at the end of this article; these are the people leading the robot revolution.

Richard Wagenmakers

Partner KPMG Management Consulting

Introduction

In this article we offer a starting point for dialogue on the opportunities offered by social robots and the potential impact on your organization. We start by identifying what a social robot is and review some key robot statistics. We present key drivers for the adoption of social robots and the economic sectors where we expect to see their introduction over the coming years. We want to build awareness on the increasingly complex social roles that robots may be able to fulfil in the future and we offer a glimpse inside the minds of four Founder / CEOs that are building robot companies.

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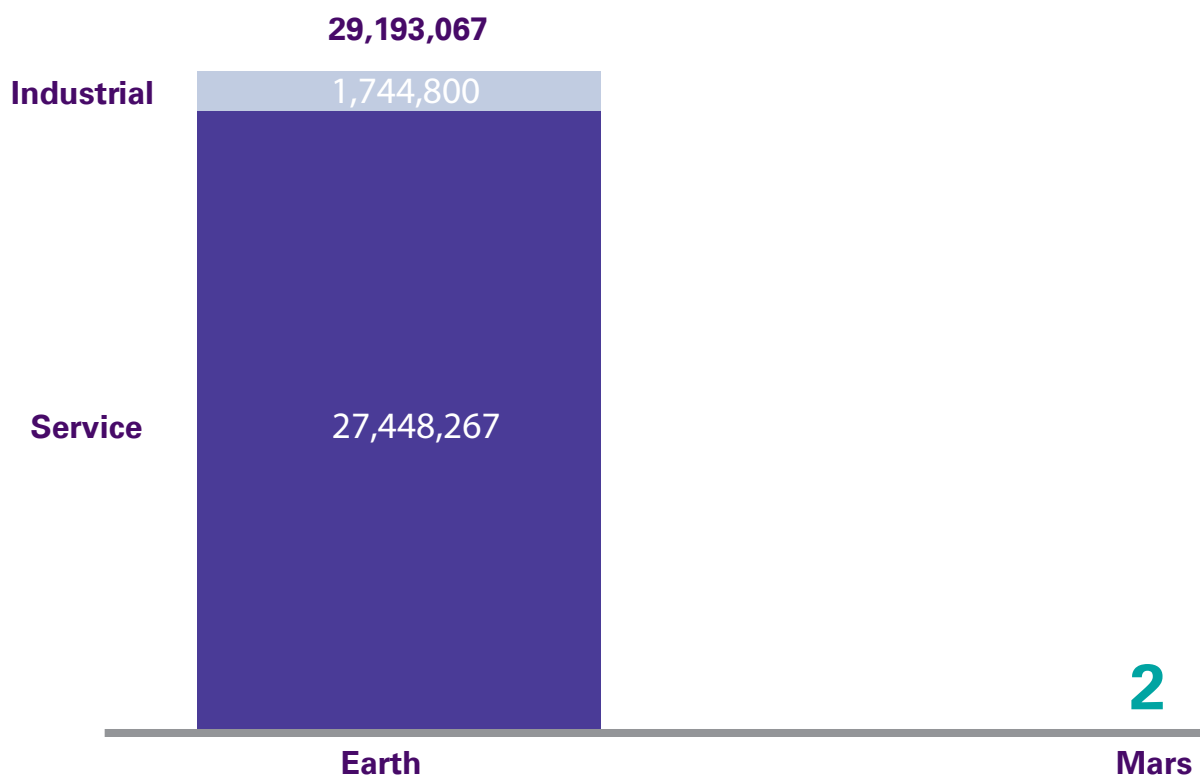
A

A new type of robot is coming to town

Robots are programmable devices that automatically perform complicated and often repetitive tasks. If you heard about a robot that could interact with you and become a helpful aid in your daily life, would you want to learn more? If so, 2016 is going to be a year to remember, because the first batches of social robots are shipping right now.

What is a social robot? Robots are already a familiar sight in our factories and warehouses, where they continue to win terrain. These robots, however, typically operate in highly structured environments and have only limited interactions with humans. Indeed, their arrival has often led to the replacement of the human workforce altogether. Now, with an accumulation of innovations in artificial intelligence (AI), sensors, and battery technology, robots have acquired the ability to enter our domains at work, home, and in the public sphere. Social robots are autonomous mobile machines that are designed to interact with us and exhibit social behaviors such as recognizing, following and assisting their owners and engaging in conversation.

Number of active robots

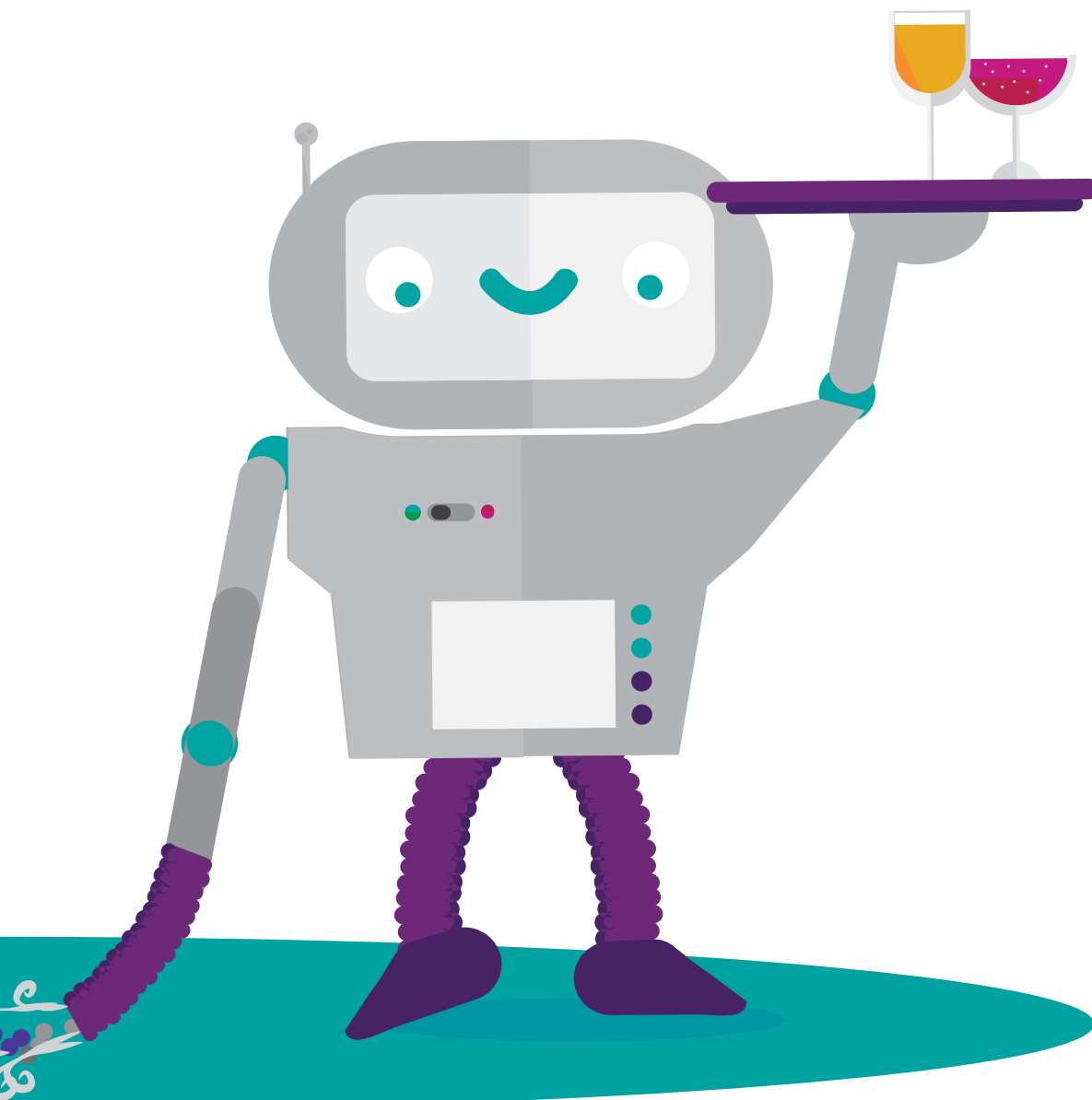


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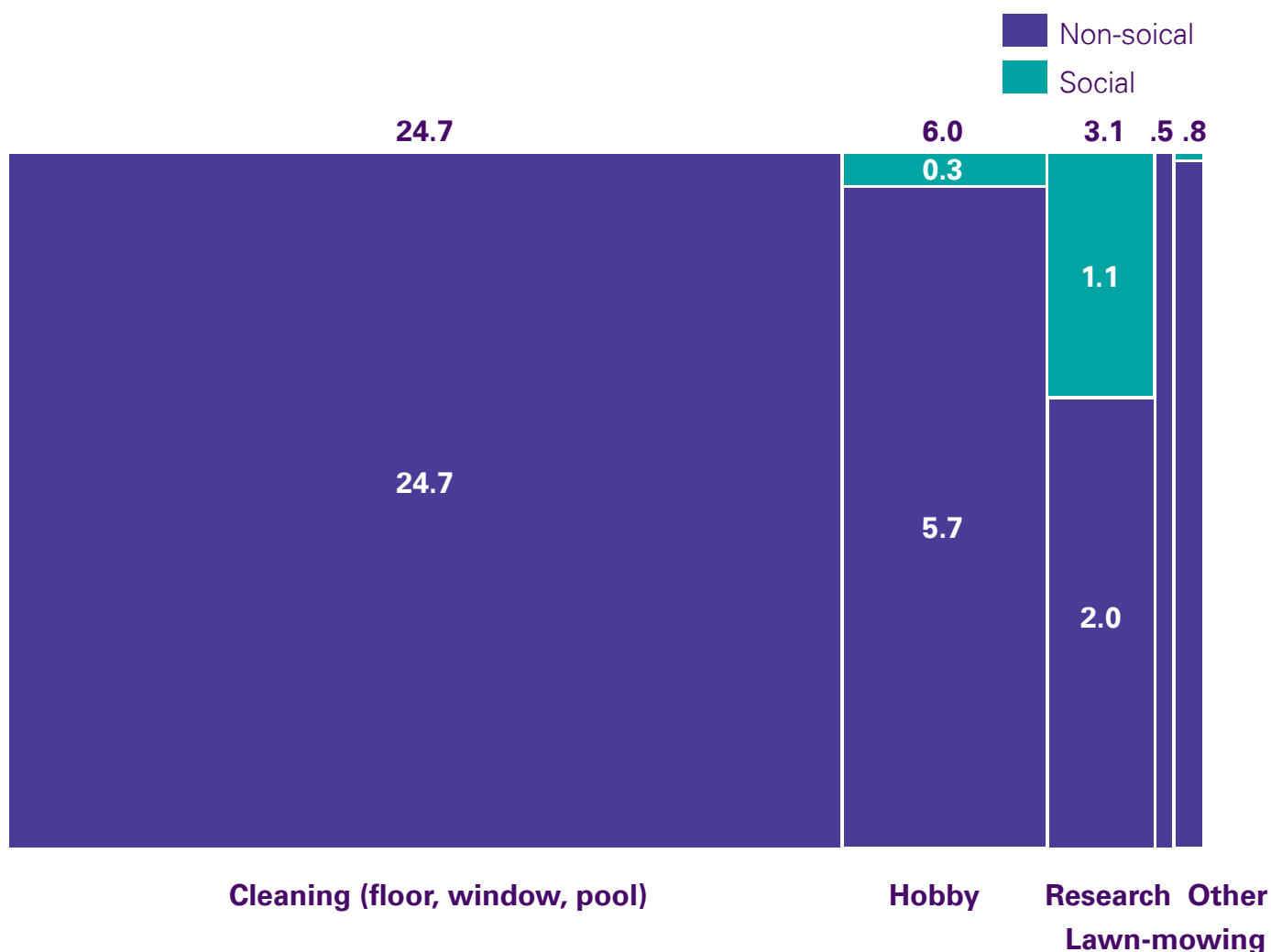
Robot categories and key statistics

The movie 'I, Robot' has an interesting perspective: fast forward to the year 2035. The streets are filled with humanoid robots that assist people with their day to day activities, while humans in need have been given robotic limbs. Yet, before we explore the future, it may be helpful to review some of today's statistics. The International Federation of Robotics classifies robots into two

categories: industrial (e.g. car manufacturing) and service. The latter is further divided into professional (e.g. milking robots) and personal (e.g. vacuum cleaners). Currently, there are about 1.7 million operational industrial robots globally¹. In total, there are ~30 million active robots, the majority of which are vacuum cleaners. This means there are ~250 humans to every robot. The industrial stock is set to grow by 35% over the next two years. In addition, based on company forecasts, more than 150,000 professional service robots have already been, and will be, installed in the period 2015-2018. Sales of personal service robots are estimated to be ~35 million units between 2015 and 2018, with ~1.5 million of them having social robot characteristics. More than 7,000 Pepper robots, for example, have been bought for homes across Japan since they went on sale there in June 2015².



Personal robot sales 2015 - 2018 (million units)



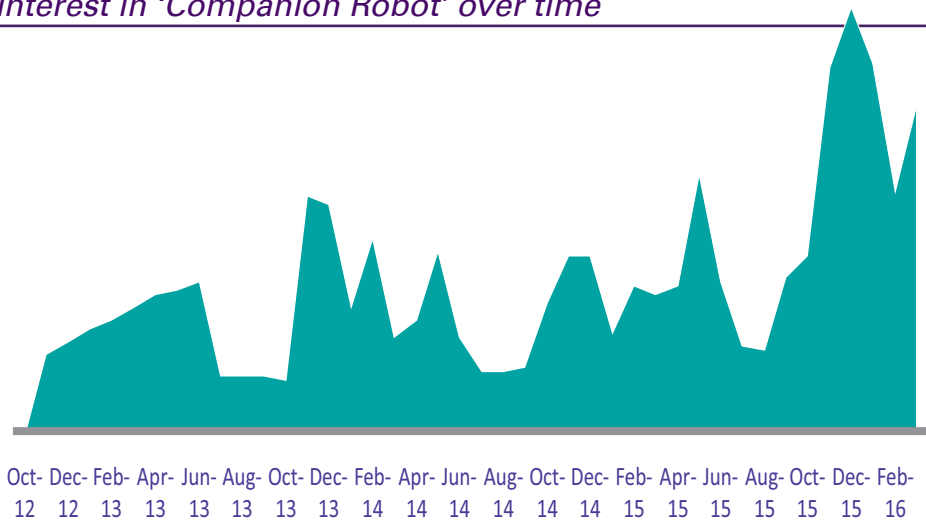
Forecasting the diffusion of new technology is notoriously difficult. A compounding factor when it comes to robots is the complexity of their systems, which typically include refined mobile hardware and AI software. Nevertheless, there are a number of indicators signaling that the time for rapid robotic progress is upon us. First, breakthroughs in AI are being made frequently. Self-driving cars are a much cited example, and think also of how Google's Deep Mind has recently learned how to beat one of the best human 'Go' players; Go is more complex than chess and the expectation was that man would continue to reign supreme for the coming decade. Second, continued miniaturization efforts and progress in material sciences has led to the most intricate mechatronics yet such as robot hands that move in the same way as ours.

Third, the price of robots continues to fall, and the new breeds presented in this article have price points that make them accessible to many different constituencies. Although Moore's law arguably no longer applies, the cost of key robot components like sensors is still falling. The average price of sensors has halved over the past decade, all while their quality has improved (see graph: Average sensor cost). Public venture capital investment in robotics also doubled in 2015, signaling a tipping point that is set to drive continued development (see graph: Public venture capital robotics investments). Finally, there is anecdotal evidence that society is more open to accepting robot companions, not just in Japan³, but globally (see graph: Interest for 'Companion Robot' over time).

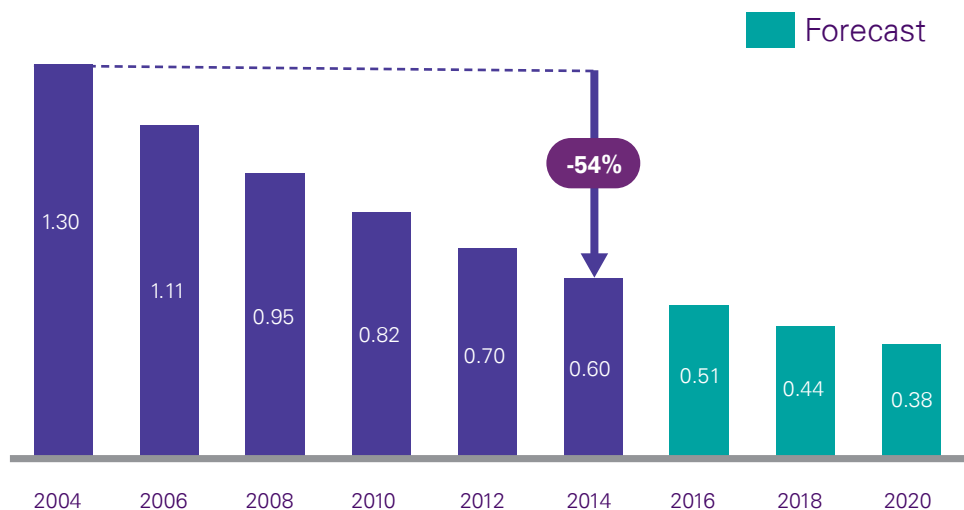
Dozens of innovative companies are shaping a future where robots will increasingly become part of everyday life. A wave of interesting robotic applications is coming to the market, with examples such as bell-hops that deliver extra toiletries to hotel guests, hospitality robots that welcome customers to a store, family assistants that read recipes and keep track of everyone's calendar, and robotized walkers that enable the elderly to adopt a healthier lifestyle. This article contains a robotic rundown which showcases several of these robots and their makers. By definition, this list is not complete: there are more social robots in development and software updates can potentially and retroactively make existing robots more social going forward.

We believe that the robots considered here are illustrative of applications that will emerge over the coming years. Our goal with this article is not to make exact predictions or steer readers towards deploying these new technologies. Instead, we hope that this article will act as a conversation starter so that leaders in this field can explore the potential impact on customers, colleagues, organizations, and society as a whole.

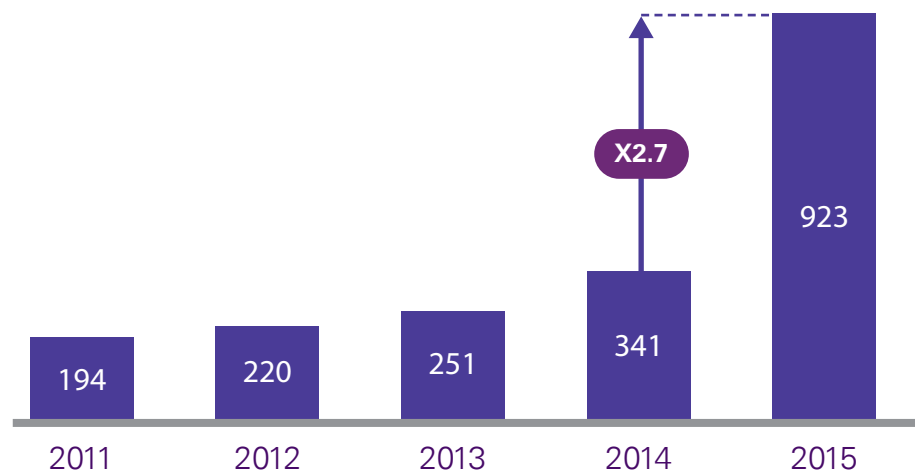
Interest in 'Companion Robot' over time



Average sensor cost (\$)



Public venture capital robotics investments (\$ million)



C

Social robot adoption: key drivers and leading sectors

We have identified eight key drivers for the adoption of social robots. These can be used to assess to what extent your industry, organization or even specific departments/teams can be a fertile breeding ground for social robots.

Social robot adoption drivers

- | | |
|---|--|
| 1 | Customer / patient demand |
| 2 | Innovation budgets / subsidies |
| 3 | Average wage |
| 4 | Simplicity of work processes (social and physical) |
| 5 | Technological literacy of personnel |
| 6 | Risk to humans (physical and mental risks) |
| 7 | Availability of personnel |
| 8 | Union power |

1. Organizations whose customers or patients demand robotic solutions are expected to lead the way in the adoption of social robots. Think, for example, of people asking for the adoption of robotic walking assistants that also remind their elderly parents when to take their medicine (see LEA in the interview section). Initial reports from the deployment of Relay (a robot built by Savioke) indicate that hotel guests are so happy to see it that they instantly share pictures of it on social media.

2. Another driver is the availability of innovation budgets or subsidies. Organizations that allocate funds for innovation are more likely to experiment with social robots and explore the implications for their processes and potential business model or value chain position. Alternatively, subsidies can drive the adoption of social robots by both established players and start-ups. Over the last few years, for example, research projects in robotics for the elderly have had a total budget of €50 million funded by the European Union⁴.

3. High average wages can encourage business leaders to investigate options for (partly) automating certain work. This then releases some of the capacity of the human

workforce to focus on tasks where we have an advantage (such as creative thinking). Social robots, like other types of automation, can be both complementary to or a substitute for conventional labor. In an ideal world, automation would result in greater productivity, thus potentially leading to higher wages. Graetz and Michaels (2015)⁵ have found that increased robotic automation leads to higher added value and labor productivity, although there is also some evidence of the crowding out of low and middle-skilled workers (in factory work). The future effects on productivity and labor aside, a broader value case conversation is required when deploying social robots.

4. The simplicity of work processes can drive the adoption of social robots. When the process at hand is relatively simple to execute, it can be automated more easily. Conversely, if the logic required to execute the process is complex, it may be harder to automate. Tasks which occur in a structured environment are easier to automate than those in an unstructured setting. Interactions with humans that require a complex set of social rules are more challenging when it comes to automation than those that are merely transactional

(compare, for example, the delivery of an additional towel to a negotiation to help someone take their medicine).

5. Another key factor for the adoption of social robots is the technological literacy of their future colleagues. When workers have positive experiences with using technology like computers, tablets, and software to make their lives easier, they will be more inclined to allow social robots into their midst as they have a positive perception of the usability and ease of use of the new technology.

6. The real and perceived risks social robot deployment poses to humans can drive down their adoption rate. In terms of real risk, it is helpful to distinguish physical and mental risks. The former is the potential damage caused by a robot interacting with a person in an unintentional manner. There have been several dramatic incidents with industrial robots, for example⁶, with a Korean woman 'attacked' by her vacuum cleaner in 2015⁷. Mental risks are more subtle. Compare, for instance, the apprehension some elderly humans feel about using their hearing aids. Studies indicate that a factor in this resistance is the fear of being regarded as incompetent⁸.



Robots designed for the elderly may thus suffer from a similar stigma, with elderly patients seeing the use of such a robot as an indicator of the loss of some of their previous ability. Alongside these real physical and mental risks is the perceived risk of social robots. Reports from the first deployments of the social robots discussed in this article are generally positive, i.e. people enjoy interacting with these machines. However, the public discourse is increasingly centered on what has been described as the 'A.I. panic'⁹. This issue revolves around machine intelligence with a 'recursive self-improvement' capability. Business and academic leaders have spoken of the danger of sentient AI, which may eventually result in the extinction of the human race. This negative discourse may instill a fear of robots in some individuals. It should be noted that those at the forefront of developing

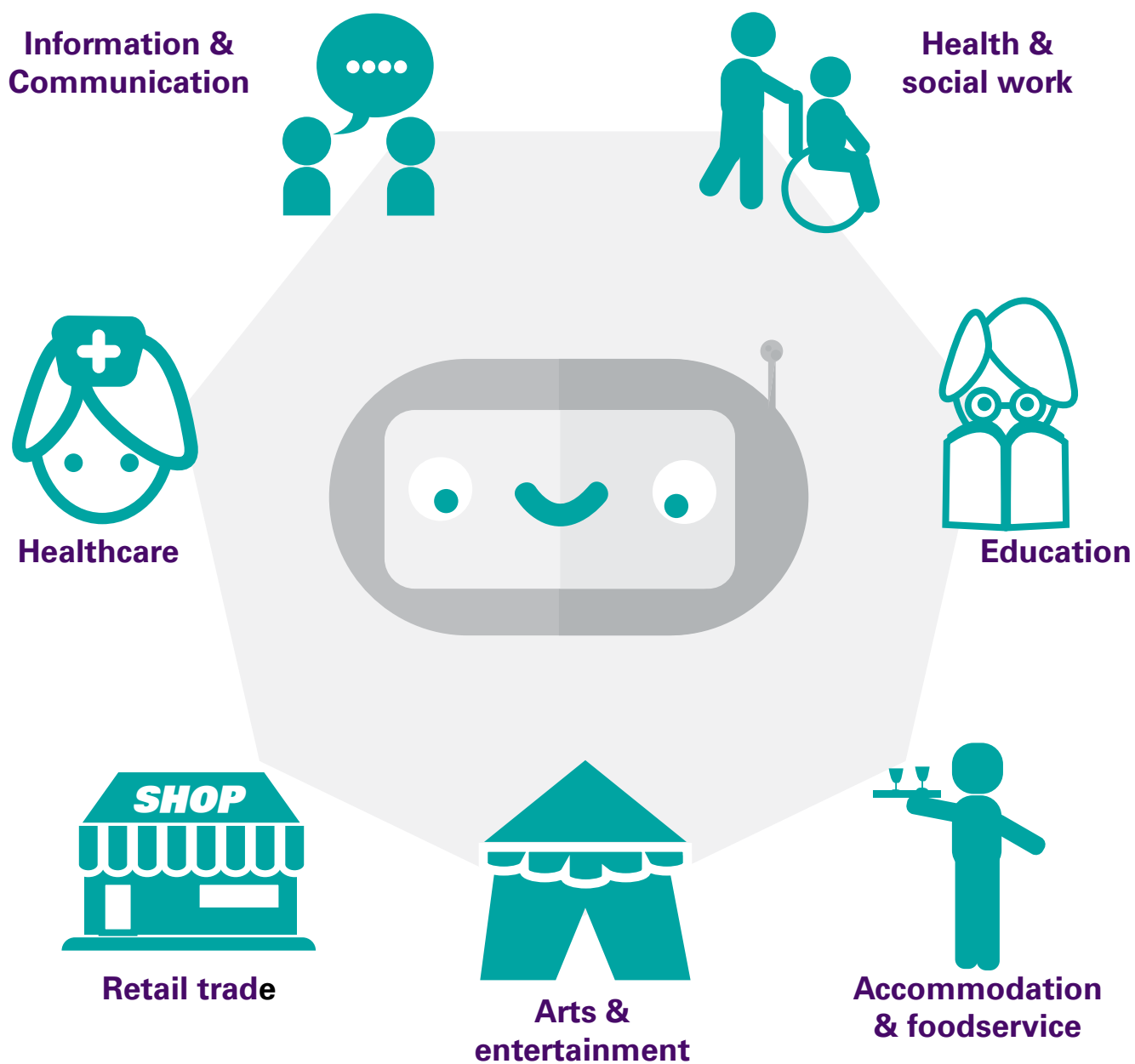
AI code generally have a much more nuanced view. To quote Andrew Ng, Chief Scientist at Baidu: "There's a big difference between intelligence and sentience. There could be a race of killer robots in the distant future, but I don't worry about AI that turns evil today for the same reason I don't worry about the problem of overpopulation on the planet Mars."¹⁰

7. Availability of personnel: if there is a high availability of workers, there will be a lower drive to deploy social robots. We note there can be a causal relationship between wages and availability of personnel (e.g. paying higher wages leading to more people willing to do the job). However, it can be difficult to find people to undertake certain tasks, such as those that require expert skills or occur at unfriendly hours or in more dangerous / unwelcoming environments.

In those situations that lead to a low availability of personnel, using robots may be an attractive option.

8. Finally, another factor that may limit the adoption of social robots is the power held by trade unions. While some unions are modernizing and more open to considering the potential benefits of automation, unions in general tend to oppose any technology that may replace (parts of) jobs¹¹. Based on the drivers above, we have reviewed twenty-one NACE codes (framework used by the European Community to collect statistical data on economic activities) and identified seven sectors where we expect innovative organizations can lead the way in the adoption of social robots. It can be helpful to take a tailored snapshot for your organization.

"I don't work on not turning AI evil today for the same reason I don't worry about the problem of overpopulation on Mars."

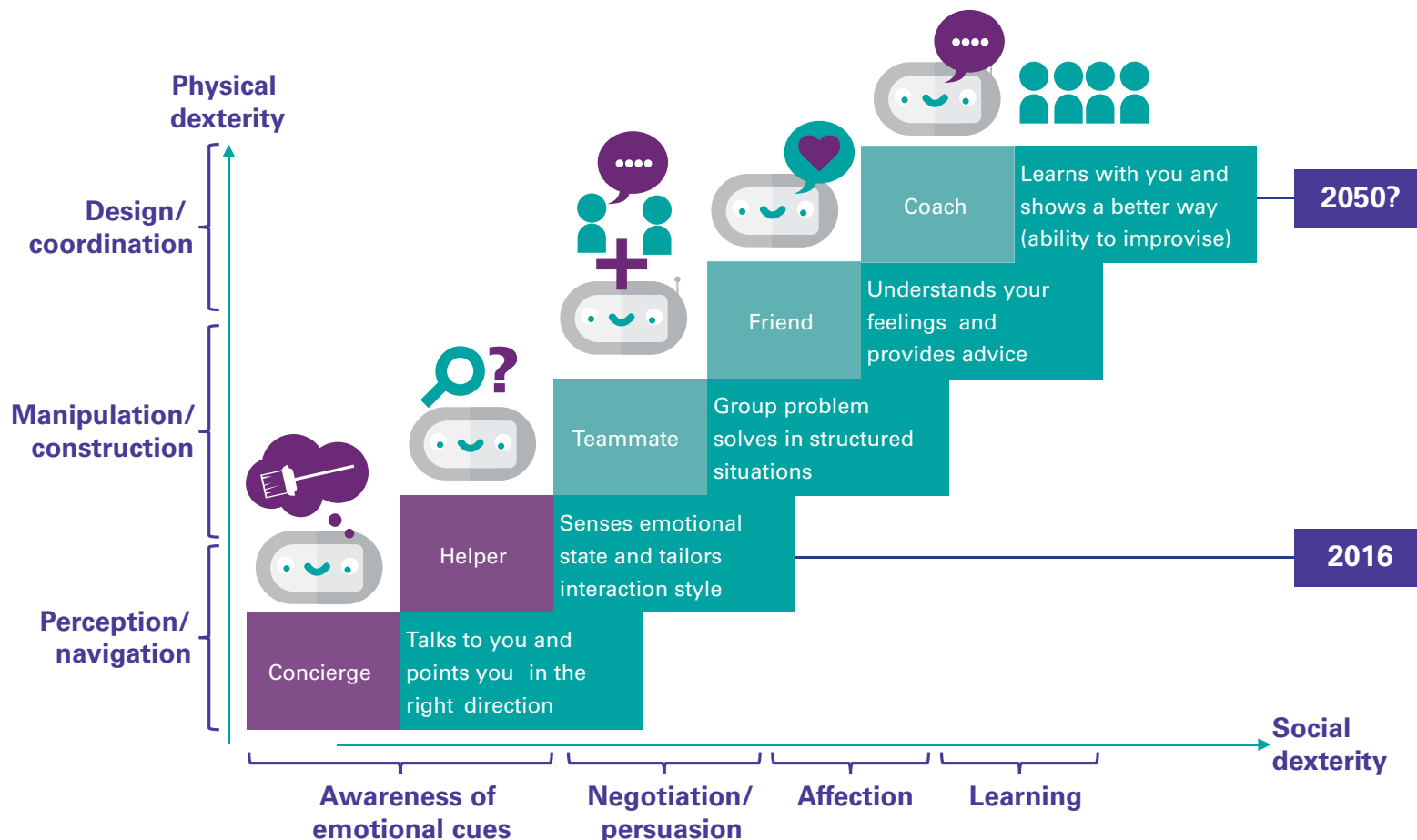


D

As their dexterity improves, robots take on increasingly complex social roles

With advances in AI and physical robot designs, these machines are taking on an increasingly complex array of social roles. We have produced the diagram below to initiate dialogue on the changing types of role that can potentially be fulfilled by robots in our homes, workplaces, and public spaces.

Social robot roles in human society

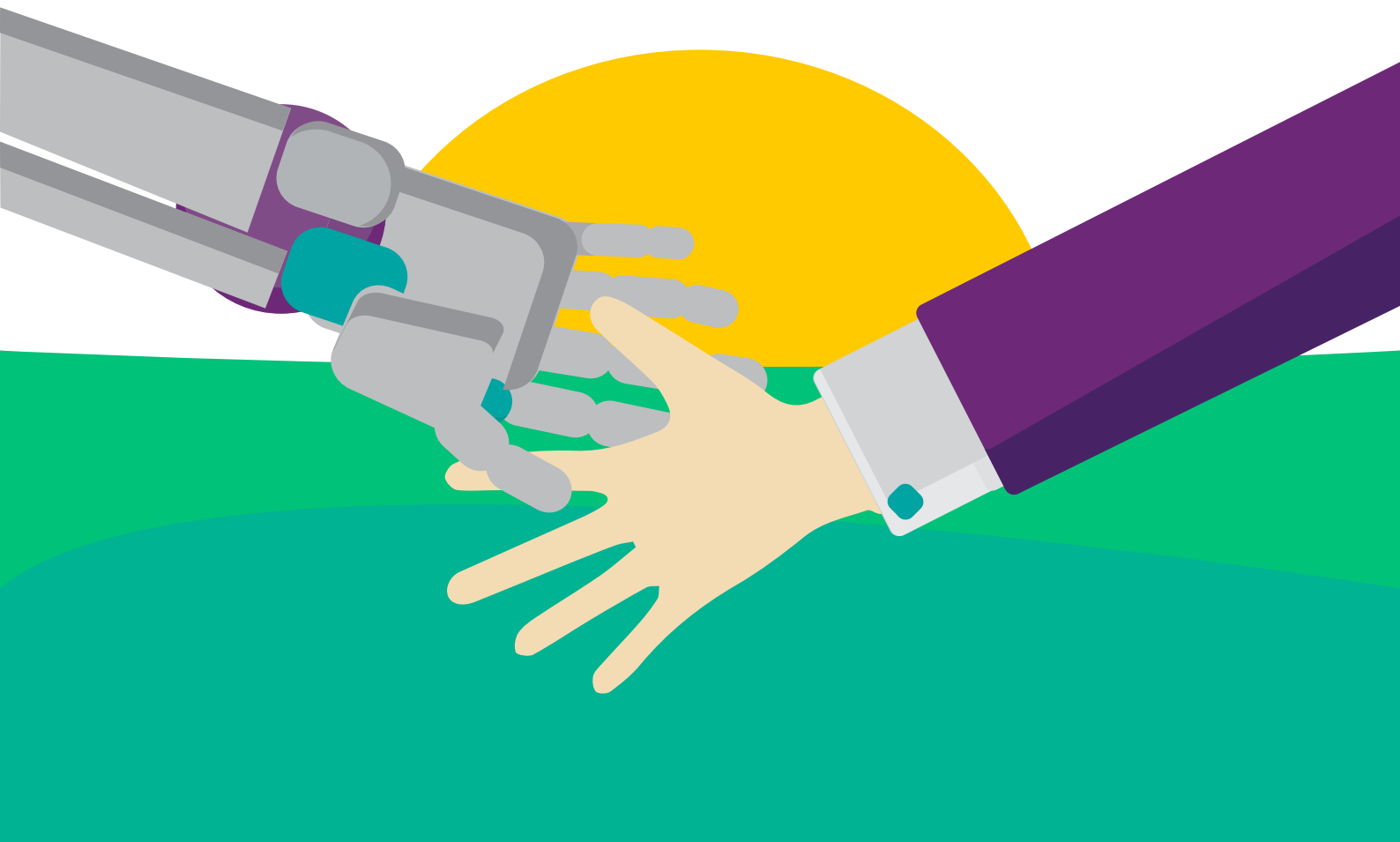


At the start of the social dexterity (i.e. handiness) axis is the absence of any social relationship. Instead, the interaction is purely transactional and the robot does not take up any social space (think, for example, of the I.V. station¹⁴, which is a robotic station that mixes intravenous solutions for use in hospitals). As the social complexity of a task increases, robots may need to be aware of emotional cues such as joy, excitement, or anger. Think, for instance, of a robot sales assistant that reacts to the delight of customers at the demonstration of a certain product by explaining additional characteristics or signaling interest to a human nearby to 'close the sale'. Even more complex social settings would require robots that are able to negotiate with human actors: imagine a robot that finds creative ways of encouraging the elderly to leave the house or start an exercise routine. The next wave in social dexterity may include robots that can build on their emotional awareness and negotiation skills to develop affective relationships with the user. In the ultimate socially complex setting, a robot would need to have the ability to learn by applying existing knowledge in a new environment and then transfer that learning to its human counterpart. It should be noted that, currently, AI is only able to 'see' basic emotional cues when they are expressed

very clearly, meaning that robots are not yet able to pick up on the many nuances of typical human interactions.

Physical dexterity relates to the difficulty of what is required to happen in the physical environment. At the start of the physical dexterity axis are devices that cannot 'see' the world and are immobile (e.g. Amazon Echo). At the most basic levels are tasks that require perception and navigation, such as delivering a toothbrush to a hotel guest or playing hide-and-seek. More complex tasks involve the manipulation of objects or construction work, such as those found in cooking processes or clearing trays from a table. The most complex physical tasks require the design of new objects, the capacity to coordinate multiple objects, and the ability to develop new solutions through improvisation/developing logic.

Note that our diagram shows the progression of machines that are increasingly dexterous, both physically and socially. In reality, the interfaces we choose for social AI purposes may be very different. Think of an evolved version of AI assistants like Siri/Cortana/Alexa that live in the cloud and interact with you via your mobile phone/television set/home computer(s). One can also imagine devices that have no physical dexterity, but



are very social (a 2025 version of Amazon Echo perhaps?¹⁵), while, alternatively, we may choose to develop machines that completely mimic, or even improve upon the human physical form, but are socially as limited as theme park animatronics.

Also note that some robots can already 'act out' some aspects of the roles depicted. A humanoid robot that demonstrates a morning physical routine for the elderly or portrays yoga poses acts as a coach, for example. The affective relationships that some owners have developed with their AIBO robot dogs are also well documented^{16,17}.

So, when will human minds become smart enough to develop synthetic minds that match our own? This type of intelligence is referred to as High Level Machine Intelligence (HLMI), and there is some consensus on when you will have the opportunity to mingle with robots that possess it. Vincent C. Müller and

Nick Bostrom conducted a survey in 2013¹⁸ that allowed 170 experts to predict when they expect HLMI to arrive. The median estimate of the respondents was that there is a 50% chance that HLMI will have been developed around 2040-2050, rising to 90% by 2075.

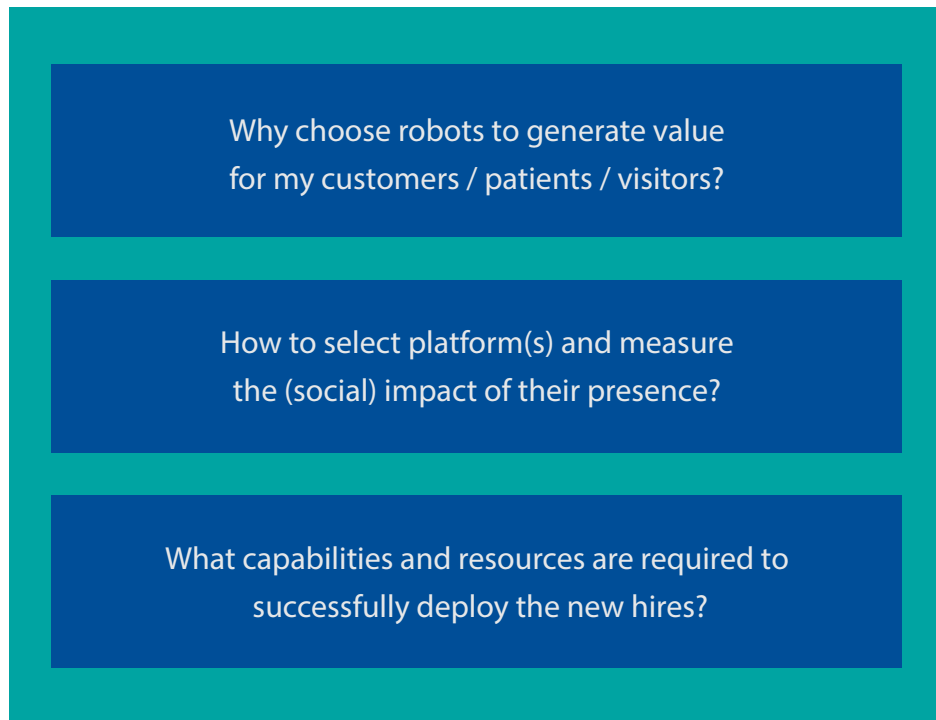
In light of this prediction, it is important to highlight three perspectives that are shared by the four robot company founders/CEOs we interviewed for this article:

1. Robots will become part of our lives long before we develop High Level Machine Intelligence – current Artificial Intelligence is limited
2. Be careful when designing the social aspects of robots: humans need to remain in charge of social relationships
3. Focus on developing robots with use-cases that work and add value today

E Do you want to explore the potential of social robots in your organization?

Social robots can potentially deliver great value and therefore hold great promise for business and society. Through learning effects, early adopters stand to gain competitive benefits in terms of quality, efficacy, durability, speed, and cost. Moreover, deploying social robots may unlock significant value gained through human-robot interactions. Robots and humans can learn to work together and complement each other. Think, for example, of a Da Vinci surgical robot, but now with strong AI suggesting alternative options to the surgeon. Or, in the more commercial arena, a robot that senses why a customer is hesitant and suggests alternative approaches to the human salesperson. Further, in the world of elderly care, a robot can encourage its owner to keep moving and visit friends, creating a virtuous cycle of healthy behavior.

When you want to explore how social robots can help there are three questions to answer:



We argue that business leaders require a compelling story to convince organizations to explore the use of social robots (including the value case). To optimize the social robot added value, we propose piloting robot platforms and experimenting with new processes in a structured manner, measuring a relevant set of KPIs. Finally, changing (service) processes can be challenging and time consuming, for example, workers may require training and other tools if they are to work effectively with social robots.

Get to know 2016's new robot breeds and their makers

Robot Care Systems

Robot Care Systems builds robots for elderly care purposes. The company was founded in 2014 and is headquartered in The Hague, the Netherlands. Its mission is "To provide a little help to keep your independence as you get older. You can continue to enjoy life." In 2015, the company won the Shell Livewire and the Herman Wijffels innovation awards. It has developed the LEA robot (Lean Elderly Assistant), which will be launched this year. LEA provides help with walking and assists users to adhere to their daily routine and, for example, indicates when medications should be taken or that it is time to exercise. LEA thus helps people to lead an active life, and ensures safety and easy communication. The device is packed with sensors to guarantee the safety of its users.



Interview with Maja Rudinac, CEO Robot Care Systems

Why did you and your team build LEA?

"We want to help the elderly to improve their quality of life during their final 20 years by allowing them to remain mobile."

What can you tell us about LEA's value proposition?

"It makes people more mobile. It assists people in getting and standing up and helps with the simple things so that care workers can focus on social contact. In short, it makes the elderly more independent, more mobile and safer."

How are you going to pilot LEA?

"We'll pilot it in five countries with five month trials that involve all relevant stakeholders: the elderly, municipalities, insurers, physical therapists, nursing homes etc. We'll test it in two settings: with the elderly who we hope to enable to live alone for longer, and in care homes."

How will staff know the robot is performing as it should?

"There are a number of indicators on the robot. We've also developed an extensive man-

ual and will provide training.”

What are the key lessons from early deployments?

“There’s a major challenge in making a robot that’s robust enough for use in the real world. Performing a task once in the lab isn’t enough; it has to be able to deal with all kinds of practical challenge. Also, the technology needs to be adjusted to people, not the other way around. We’ve concluded that, with robots, simplicity is the ultimate sophistication.”

What are your key market segments?

“We’re focused on elderly care and rehabilitation. In the future, we may develop additional solutions for hospitals (e.g. moving goods) and we hope to make our robots fit for outside use as well.”

How do you see the future of social robotics; how social should robots become?

“This is an important political choice we have to make. I believe robots are primarily a tool and they should become as social as would be required for them to navigate our world. But we, people, should take the lead in social interactions. Robots shouldn’t replace humans in a social setting, but they should augment and complement us. We have to be careful. Think, for example, about chat machines that mimic humans. What if, for some people, there’s no longer a reason to leave the house? Machines shouldn’t change the social contact we have.

There are specific situations where a certain level of attachment to the robot may be desirable, for example in cases of dementia, autism, and for those with mental disabilities.

But let’s make sure we’re very clear on the following question when we create a new robot: how will it help people or the planet?”

What’s your perspective on artificial intelligence?

“The biggest challenge with robots is that they can’t apply existing knowledge in a new environment. I don’t agree with the current trend in robot design where it seems the objective is to mimic a human. My suggestion is to start small with robots that solve specific problems and then build on that.

Many scientists in the field expect robots to be at a general level of intelligence around 2050. That’s when they should be able to compete with the best human players in soccer. But they’ll be entering our society much sooner.”

What are the key drivers for social robot adoption in your view?

“Robots have the ability to take over repetitive tasks, secure buildings, enter dangerous areas where humans can’t or don’t want to go. Also, the susceptibility of humans to new technology is key. In general, I find people are quite open to new technology; think about cell phone adoption for example.”

How should organizations prepare for the introduction of social robots?

“Be open to new technology. Find ways for humans and robots to work together, with the robot as a helpful tool. It’s also key to prepare humans through an appropriate training program.”

“technology needs to be adjusted to people,
not the other way around”

Savioke

Savioke (pronounced savy oak) wants to enable hotel personnel to provide better customer service. The company was founded in 2013 and is headquartered in Santa Clara in the United States. It is passionate about delivering easy-to-use, yet sophisticated, robots that can help people. The aim is to improve lives by developing and deploying robotic technology in the places where people live and work. Savioke also believes in the power of open source software. The company leverages and contributes to the open source Robot Operating System (ROS) that it helped to develop at Willow Garage. Savioke was given a GameChanger award by the Robotics Business Review. The company has developed Relay, a robot that relays products from one person to another. The first application is in the hospitality industry. Relay is 91.4 cm tall, weighs less than 45kg, and has a carrying capacity of 0.06m³

Interview with Steve Cousins, CEO Savioke

You have extensive experience with robotics, why did you choose to develop a robot for the service industry?

"We knew we wanted to continue down the autonomous path and we looked at the cost factor. One of the first questions we asked was: should we be in commercial environments or the home? We landed on the goal to develop an affordable robot for the service industry after we had an 'aha' moment. Robots are most helpful when there are repeatable activities that have to occur often. Think, for example, of hotels, restaurants or elderly care. These work environments feature tasks that occur many times throughout the day.

We looked at a number of industries and had to pick one. The fundamental factor we bring is safe and reliable mobility in human spaces. Not getting lost, moving gracefully, and using the elevator. We started in a domain that has three year olds running around. We see an opportunity to leverage the lessons we are learning in other environments that require a high safety standard."

What's your perspective on social robots?

"We set out to build something useful. Robots are there to do work. We recognize that the technology that we build will be treated by people as if it's a social actor. One question is whether you start to design it to be social. We could also build a robot that isn't very social. We're providing a platform for safely and reliably navigating through human spaces. We've had robots working in hotels for over 1.5



years now. As we deploy the robot there are all kinds of interaction. The robot has necessary interactions for it to do its work (deliver products) and then incidental interactions (as it encounters people in the hallways).

It all depends on how we can improve guest satisfaction and the goals of the hotel. We started with service robotics and ended up adding the social element. The question came up: should we put eyes on it? We went for the middle ground. We're currently adding a 'mingling' activity to the robot. Our mission is to deliver – be as cute as you can, but do useful work first.

Take speech, for example. We find some people prefer interacting with machines through a touch screen as it creates less social anxiety. Some may expect a speech capability and would want to talk to the machine. Over time, we plan to meet the wishes of people at that level. It's not one or the other. It makes sense for us to add features when we feel the time is right.

The most successful social robots have been the ones where the people they are interacting with have a need for a social agent. Humanoid robots, but not too humanoid, for children with autism, for instance. For example, Paro has been used in Denmark to help dementia sufferers speak again."

What type of metrics do you gather in your current deployments?

"We measure how often the robot is used. Also, the number of deliveries per day and the success rate. We're consistently driving that upward and we're already in the 98% percentile."

What's your view on AI?

"I'm a skeptic about AI. Robots don't have common sense. We try to have a robot that works as much of the time as possible and otherwise it falls back to a human brain. Think, for example, of an issue that we encountered. The robot has to take a delivery to the 7th floor and somebody on the 3rd floor pushes the robot off the elevator. Someone will then remotely restart the delivery and the customer won't even know something was wrong. Eventually we'll solve this autonomously."

How do staff members interact with the robot?

"Staff members can pay attention [to it], but they don't really have to. We position Relay as a service robot; they don't have to worry about it. We give staff the ability to monitor the robot. They can monitor it from their station. But it can also function as a fully autonomous tool. The relay is from one person to another, a baton from a staff member to a guest."

What was the biggest surprise you had based on your deployments so far?

"We were really surprised by guests' delight. Many people go on social media and post selfies taken with the robot. Also, staff reactions were a very positive surprise. Unfortunately, the media has created the idea that robots are here to take our jobs. Actually, when one of the robots was offline, the hotel staff was sad that their 'co-worker was out of service'; they celebrated when he came back online. We're automating tasks, not jobs. People have so much more inherent capability that's released by automating low-value tasks. Societally, ev-

"Hotel staff was sad that their 'co-worker was out of service' and they celebrated when he came back online"

ery time we've had more automation, we've had more wealth as a result."

How are you approaching the market?

"We're talking to the brands, talking to hotel owners and managers. A big benefit is that robots in hotels are easy for reporters to see and are highly photographable; we've received an enormous amount of press."

What's your value proposition?

"We provide robots as a service. We perform the installation and integration with the building infrastructure and phone system. We can't drop-ship it at the moment; there's an installation step. In terms of cost, we were able to create a design that comes in at a cost that's significantly lower than the lowest-cost worker. Also, the robot is always available. Note that because we provide the robot as a service, it's our responsibility to keep the fleet operating. If there are issues, we pay for service visits. So that aligns incentives so as to create a highly reliable, quality product."

Note that because we provide the robot as a service, it's our responsibility to keep the fleet operating. If there are issues, we pay for service visits. So that aligns incentives so as to create a highly reliable, quality product."

Who are your key partners?

"We're looking at the supply chain. We're exploring relationships with contract manufacturers to take on more of the assembly tasks. Then there are installation partnerships with companies that have personnel globally, and we're also exploring sales/distribution partnerships at the moment."

What are the key drivers for Relay's adoption?

"Fundamentally, guest satisfaction drives adoption the most. Service robots cost effectively improve the level of service that a hotel

can provide. They're fast and remove social awkwardness from the equation (how much to tip, having to get dressed). The same approaches will work in other domains as well. For example, hospitals are judged by patient experiences and service levels now."

How should organizations prepare for the introduction of social robots?

"Organizations that succeed are those that manage to improve their service processes. You've never read a resume that says: I can ride the elevator all by myself; I can walk the hall all by myself. Our robot does a couple of things very well, which allows staff to expand what they are doing in terms of service processes."

What's your ambition? What does the impact look like?

"We want to put robots in the world to help people. Helping people do their jobs and provide higher levels of service. Helping people to help themselves. Think about people with disabilities who are completely dependent on caregivers. I once worked with a mute paraplegic who used a robot as his external body. He controlled it by moving his head. He turned the robot towards himself and put the robot arm to his face. We were worried, because we didn't know what he was doing... then he scratched his nose. It was the first time in ten years he was able to do that! This is what robots can do - help people who can't help themselves."

Savioke as a company wants to improve users' quality of life. At the same time, we're a commercial company and are looking for lucrative markets."

Blue Frog Robotics

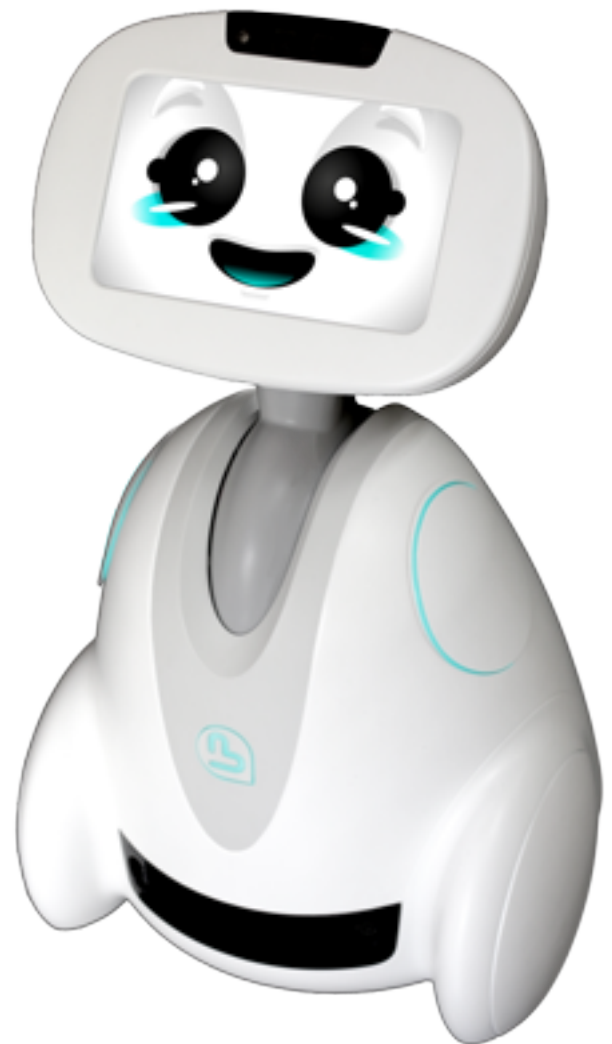
The company's goal is to "design and develop robots that are accessible to everyone and help people live easier and safer lives, and have fun." The company was founded in 2014 and is headquartered in Paris, France. The target market is families, although it is exploring business applications as well. The company has won the 2016 Juniper Research Future digital award in the category 'Best Emerging & Disruptive Consumer Product'. It has developed the Buddy robot, which will be launched this year. Buddy is a companion robot developed to improve the everyday life of the user. He protects your home, offers assistance in the kitchen, entertains the family with music and videos, acts as a calendar and alarm clock, and interfaces with popular smart home solutions. Buddy is 56cm tall and weighs 5kg. His brain is an integrated android tablet. He is able to hear and speak thanks to built-in speakers and a microphone array system. He is fully mobile, with three wheels, and is equipped with a variety of sensors to deliver various functionalities. These sensors include a 3D camera, ultrasound, infra-red and thermal sensors, a range-finder sensor, and ground detectors. The sensors, coupled with Buddy's mobility, mean that he can travel autonomously and learn and interact with the world around him. Buddy is built on an open-source technology platform, and developers across the world can easily collaborate to build additional hardware and software for the device.

Interview with Rodolphe Hasselvander, CEO Blue Frog Robotics

Why did you start Blue Frog Robotics?

"I had a dream of a companion robot when I was younger and that dream is still very much alive today. After developing robots for nuclear, healthcare, and defense applications, I believe the time for consumer robotics is now. With vacuum robots and drones in many homes, the general public is ready to accept a robot companion. Many people are already aware of how to use tablets and touch screens, so that's one of the reasons we built Buddy with this standard technology."

BLUE FROG
THE ROBOT COMPANY



What were the goals when designing Buddy?

"When we set out to design Buddy we had two goals. First of all, we wanted the robot to be accepted by people. Therefore, it had to be cute, 'Kawai'. Secondly, it had to be accessible, because we want to democratize robots. The challenge we faced was to create a cute robot that people want to bond with while using accessible technology."

What markets are you targeting?

"The original idea of Buddy was born out of the need to help the elderly to live alone for longer. Many elderly people love our prototype. However, there was a risk that they would have the same concerns that many have about using a hearing aid: "Am I that old?" For this reason, we started testing Buddy in family units as well. Our thinking is that when elderly people see families adopting Buddy, it'll become easier for them to do the same."

How do you see Buddy evolving?

"Fundamentally, Buddy's about a new way of interacting with technology. A hub to integrate all the 'Internet of Things' devices in the home, perhaps. The elderly indicate, after interacting with Buddy, they want him to teach them new skills such as learning a new language or playing an instrument. We mentioned that there are already plenty of applications available on the computer or tablet, but they insisted that they wanted to learn through Buddy, because he can offer 'character', someone to "talk to."

What's Buddy's value proposition?

"There's Buddy's ability to teach children through edutainment, for example. We're currently working on educational applications. Also, we've received very positive reactions from those working with people who are on

the autism spectrum. We're working with 'Les Papillons Blancs' (an organization that helps those with intellectual disabilities). Also, there's a real need to bridge the gap between technology and the elderly, and Buddy plans to fulfill that role.

The value proposition also depends on the country. For example, in China, we'll focus on Buddy as a children's companion. There's a market in China of ~120 million households for a companion/education robot for children. In the United States, the focus will lie on home security, as that's a key concern for many people there."

What sets the Buddy platform apart?

"We use the Google app store. Our platform will be an open network to stimulate innovation. We're working with XBrain on AI.

Also, Buddy's an "open-hardware" platform that can be expanded with accessories such as arms with a pico-projector and a side tray."

What's your business model?

"Our initial business model is to gain revenue by selling Buddy hardware and accessories. For the next phase, we aim to valorize the anonymized data Buddy gathers. We're also exploring subscription-based

models for services."

What's your perspective on AI?

"AI still has many challenges. It only works in highly structured and narrow spaces such as winning Jeopardy or doing diagnostic work. It's not ready to truly socially interact. Artificial General Intelligence may not be with us before ~2050."

What's your goal?

"We want to put a robot in every home."

"WE WANT TO DEMOCRATIZE ROBOTS"

AvatarMind was founded with the goal of creating intelligent humanoid robots to serve as helpers and companions. The company's dream is to create affordable robots that live in harmony with ordinary people and improve their everyday lives. The company was founded in 2014 and has facilities in Nanjing and Shenzhen, China and Silicon Valley in the US. Its first target market is Chinese families with children aged 3-8. It has developed the iPal robot, which will be launched later this year. The robot is a friendly companion for children to play with and talk to in a natural manner. It can dance, tell stories, play games, and enable children to chat with friends and family, share videos, and connect to social media. For parents, iPal is a teacher for their children, with spoken language learning and tablet-based educational programs. A key feature is that parents can use their smartphone to control iPal and monitor their child's safety and activity from anywhere in the world and at any time. iPal is 106.7cm tall and weighs 12.4kg. It has 25 motors, two cameras, five microphones, five touch sensors, four range finders, and seven obstacle detectors.



"IN ABOUT FIVE YEARS
OR SO PEOPLE WILL HAVE
MULTIPLE ROBOTS
IN THEIR HOME"

Interview with John S. Ostrem, Ph.D, CEO Avatarmind

Can you tell us about the start of your product – what unfulfilled need did you see?

"We started about two years ago after being in an incubation phase for a while. Our final prototype will be released in April, and we expect to begin manufacturing in the 3rd quarter of this year. Our first focus is the one-child market in China. We believe our robot can help mothers when they need a break, educate their children so they can prepare for school, make learning more fun, and enable them to monitor their safety and health."

Can you tell us what iPal's value proposition is?

"iPal is designed to be a companion for young children and to help with their education. It'll also allow parents to monitor their children from the next room or communicate with them when they are on a business trip. We developed our own software so the robot can help to educate and entertain a child in a more interactive way. We're also looking for partners to work with in specific vertical applications such as elderly care and assisting children with special needs. In fact, we already have a partner we'll be working with to deliver robot therapies for autistic children.

iPal is a complex, but highly reliable and robust, device; it will still function when it gets knocked down, for example – this actually happened at the recent CES show, when a robot got knocked off a 3.5 foot high table.

We'll have our own app store with applications that are approved for children. As a result, the children will be safe when using applications developed for our robot."

What metrics are you collecting in your deployments?

"A key part of our deployments is assessing the interaction with children. The child can talk to iPal and we need to make sure this interaction is optimal and fun. The robot should be able to hold the child's interest for a significant amount of time. This will be achieved by a combination of interesting interaction

behaviors, learning to adapt to the child's interests, and pushing new content to the robot every day. We have a large team currently working on this. For example, we're working with teachers to develop a long list of questions that children typically ask and age-appropriate answers."

What are your key market segments? How do you target these at the moment?

"We're focused on the Chinese market first. There's a very large market of one child families there. The key characteristic of these families is that they have disposable income and are known to support anything that will improve their child's quality of life, education, and security.

We're also looking at several use-cases for the US. In addition to companion robots for young children, we've received a great deal of interest in iPal for elderly care and children with special needs (especially autism).

We intend to open 'robot playgrounds' in China. Shopping malls in China are like entertainment centers and there are often playgrounds for children. This is an ideal environment for us to get exposure and feedback. In our iPal robot playground stores in major malls, children will be able to play with iPal and parents can then buy iPal robots when they see their value. It offers parents telepresence and the ability to play games with their children while they're away. And no parent just wants his or her child to sit in front of a screen all day. As a robot that can move smoothly and elegantly, iPal will also help to promote physical activity and interactivity in children."

What's your perspective on social robots?

"At this stage of development, we aren't big believers in trying to build robots that look exactly like humans. We feel the fun, cartoonish form of iPal will be both attractive to children and non-threatening to adults. Our market surveys also support this. However, it's relatively easy and inexpensive to cover the robot core with different plastics, so different form factors for different markets are definitely possible.

We also want to strongly emphasize that we aren't trying to replace parents or friends. It's about filling gaps. Likewise with autism care.

Our typical use-case would be something like this: the therapist goes in, sets up the robot program. Ideally, therapeutic interactions with an autistic child can take place up to 30-40 hours a week. If you have a therapist that can use the robot as a surrogate, the effect can multiply. We're augmenting humans to make their work more effective so that more children can be helped by each therapist. We've a lot of interest from playground and kindergarten schools in China. They typically have one teacher to take care of 20-30 children. Again, imagine augmenting their capabilities with robots, so that each child will have more one on one learning, either with the teacher or with the robot as an interactive instructor."

Who are your key partners?

"We already have a good partner to explore the use of our robot for applications in autism. The humanoid form is great for that. Did you know there are 7 million autistic children in China? We're also actively looking for partners who are experts in other fields like elderly care and special needs children."

What are the key drivers for social robot adoption in your view?

"In China, the decision-maker is the head of the family. The key drivers are the ability to improve the child's quality of life and ensure his/her safety. We emphasize the educational aspect that will give a head start in school. About 85% of the children who took part in our test will come up to the robot right away

and play with it, but others sometimes take a little longer to warm to it.

The big lever is in areas where there is a clear utility. One of the things that has been very interesting and gratifying is that when we do trade shows, so many people come up with their own ideas on how to use iPal. As an example, physicians tell us that there are a lot of children in cancer wards who are lonely and unattended for much of the time. Imagine being able to improve their quality of life. A high-end hotel chain wants to talk with us about iPal leading their clients to their rooms and then explaining all the features of the room. It even looks like iPal will be starring in a children's TV show in the future."

How do you see the future of social robotics?

"The computer revolution is over – today everyone has multiple computers in their home. The next big revolution is going to be the robot revolution. In about five years or so people will have multiple robots in their home, not just their Roomba. However, it's also important to be realistic about what robots can do at this stage of the technology if you want to be successful in commercial markets. For example, we don't believe that the technology is good enough today to develop a convincing robot that can be a true companion for adults. However, we do believe that we can build great products for young children, and for specialized applications like elderly care and children with special needs."



Would you like to learn more?

Do contact the author for more information and/or send your email address so we can share updates as the social robot story evolves.

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H Robot roll-call



Name	LEA	Relay	Buddy	iPal	Jibo	Zenbo	Furo-i	Sota	Pepper	Oshbot	REEM
Purpose	LEA helps people to lead an active life, helps with daily routines, ensures safety and ease of communication	A robot that relays products from one person to another	A companion robot that protects the home, offers assistance, entertains and interfaces with smart home solutions	A friendly companion for children to play with and talk to in a natural manner	Helps adults to manage their life, helps seniors to live with greater independence and is a playmate for children	Your smart little companion	Create closer family relationships. A connection to home devices and a companion for the family	A "social dialogue" robot	Pepper is the first emotional robot. He was designed to be a true companion for daily life	Your autonomous retail robot assistant. Empowering your retail workforce with Inventory Management and Customer Service	A friendly full-size humanoid robot that will make your event unique
Target market	Elderly Care	Hospitality industry	Families	Children aged 3-8 years	Families	Families	Families	Elderly care	Both homes and businesses	Retail	Entertainment at events, conferences and fairs
Company	Robot Care Systems	Savioke	Blue Frog Robotics	Avatar mind	Jibo	Asus	Future Robot	Vstone	Aldebaran	Fellow Robots	PAL Robotics
Headquarters	The Netherlands	USA	France	USA	USA	Taiwan	Korea	Japan	France	USA	Spain
Website	robotcaresystems.com	savioke.com	bluefrogrobotics.com	avatar mind.com	Jibo.com	zenbo.asus.com	myfuro.com	vstone.co.jp	aldebaran.com	fellowrobots.com	pal-robotics.com

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Interest in 'Companion Robot' over time: Google trends, extracted March 2016

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Social robot roles in human society: Roles and functions of robots in human society (Dautenhahn, 2002)

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